# WHITE PAPER

# **Emerging Technologies Whitepaper**

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### **Emerging Technologies Whitepaper**

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### **Section 1: Context**

Introduction

The California Public Utilities Commission (CPUC) issued an Assigned Commissioner's Ruling (ACR) regarding the first and very successful energy efficiency workshop and requesting postworkshop comments regarding steps the CPUC could take to best achieve statewide energy efficiency potential<sup>1</sup>. The ACR identified several conclusions regarding the potential for energy efficiency in California and identified several gaps that need to be addressed, including:

- The state is not currently maximizing its energy savings potential
- The state will need to promote more innovation in emerging energy efficiency technologies
- Some of the CPUC's existing policies should be modified to maximize opportunities to promote energy savings.

In addition, the ACR posited a group of questions regarding how the CPUC could improve development and market adoption of energy efficient emerging technologies. The California Energy Commission (CEC) welcomes the opportunity to provide the CPUC comments regarding emerging technologies and recommendations regarding potential improvements to state policies and programs in energy efficiency emerging technologies. We have provided responses to specific questions raised in the ACR regarding emerging technologies in the Appendix of this whitepaper.

To gain the proper perspective on the issues that the CPUC has raised, it is useful to review the historical per capita electricity use in the US and compare it to per capita energy use in the two states that have the most aggressive energy efficiency programs in the country, California and New York (see Figure 1).

Figure 1: Per Capita Electricity Use

<sup>&</sup>lt;sup>1</sup> The energy efficiency potential workshop was held on October 8, 2003. It was the first workshop in a series of workshops related to Rulemaking 01-08-028 conducted to determine how the CPUC may make the most of the state's energy efficiency resources in the years following 2005.

It is clear that California's energy efficiency programs have had positive effects. For California, electric use per capita has stayed constant for 29 years from 1975 to 2004 while the U.S. as a whole has grown 2% per year and is now up 50 % over California's per capital use<sup>2</sup>. Overall, we believe that two thirds of the US-California difference is due to California's standards programs and conservation ethic. We further believe that emerging technologies are a necessary ingredient to feed the conservation food chain.

Figure 1 shows that California has avoided 50 % of the annual \$32 billion annual electric bill, saving\$16 billion per year or \$450 per year per capita. Other studies have identified comparable levels of avoided bills in California (Rufo and Coito 2002). Without the historic energy efficiency programs, the state's energy consumption per capita would have grown more rapidly and could have equaled or surpassed the national average. Likewise, New York's strong energy efficiency programs have resulted in a per capita electric use much less than the national average and similar to California's. However, even with those significant benefits, there are large, remaining opportunities for increasing the level of energy efficiency in the state (see **Table 1**, adapted from Rufo and Coito 2002).

Table 1: 10-year Achievable Potential Results (2002-2011) by Scenario\*

(Compared to 2011 Business as Usual baseline of 310,000 GWh, 61,000 MW and \$37 Billion)

Scenario	Result	Business-As- Usual	Advanced Efficiency	Max Efficiency
	<b>GWh Savings</b>	9,637	19,445	30,090
Base	Net Savings, millions dollars	9,604	15,949	23,203
	MW Savings	1,788	3,480	5,902
	<b>GWh Savings</b>	7,569	15,949	23,203
Low	Net Savings, millions dollars	4,454	7,436	10,542
	MW Savings	1,408	2,725	4,415
	<b>GWh Savings</b>	11,733	21,146	29,199
High	Net Savings, millions dollars	15,649	23,036	29,972
	MW Savings	2,178	3,824	5,862

<sup>\*</sup> GWh and MW savings are in the year 2011. Dollar savings are net of annual cost or more efficient products, calculated using nominal discount rate = 8 percent, inflation rate = 3 percent and the service life of the product

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<sup>&</sup>lt;sup>2</sup> Approximately half of this 2% per year relative gain in electric efficiency (California versus the U.S.) is directly explained by California's codes and standards and utility-administered energy efficiency programs. The other half of the 2% per year gain is explained by structural differences and a mild climate.

Achieving additional energy savings will not happen automatically and the bridging of energy efficient emerging technologies into the market will be one of the key factors in achieving and sustaining future energy savings.

Framework for Successful Development and Market Adoption of Emerging Technologies

The overall framework for bringing innovation to the marketplace can be envisioned as a system of linked activities that create value.

- Innovations (i.e., new technologies and advances in design, construction, and operational tools and methodologies) typically flow from a conceptual stage of development to full adoption in the commercial arena via a series of linked activities. These specific activities in the innovation process are idea generation and selection, research and development (R&D), pre-commercial demonstration and promotion, and adoption into commercial arena.
- Poor linkage between these activities results in decreased delivery of innovations and value to the commercial arena. One of the key determinants for successful innovation is "institutions for collaboration" that effectively link upstream R&D with commercial deployment (Porter and Stern 2001). Without strong linkages, innovations will not be transferred effectively to the marketplace, the full value from the R&D investment will not be captured and the advances may diffuse to other regions before they are used by the region that created them.
- Without proper linkages to the commercial market, innovations are in effect warehoused (i.e., shelved or stored without being put to use). Warehoused technologies do not have unlimited shelf life—they are perishable and eventually become worthless. However, deployment of new technologies does not happen unassisted. In a colloquium of leading innovation practitioners, 50 major companies exchanged knowledge and best practices regarding innovation and they identified linking R&D activities to commercialization as one of the major historic barriers affecting innovation success (Arthur D. Little 2000).

Therefore, to capture the full potential of the value created by investments in upstream R&D, it is necessary to invest especially in the linkages between upstream R&D and the commercialization market.

Development and Market Adoption of Energy Efficient Innovations in California

The CEC's Public Interest Energy Research Program (PIER), funded at \$62.5 million annually, is the largest public interest energy research program in California and one of the largest in the country. PIER has been in existence since 1998 and an array of promising innovations are emerging from the research investments made over the past six years. PIER has played a critical part in developing energy efficiency innovations and has successfully facilitated the introduction of many of these innovations into the market. PIER uses multiple paths to facilitate innovations (see **Figure 2**). These include bringing innovations directly from the CEC PIER program to the end users for adoption and use; affecting the marketplace via codes and standards (both California T-24 and T-20 and via national codes); and linking to the end user via the multitude of manufacturers, distributors

and to the overall building industry (i.e., highly fragmented group of architects, designers, developers and contractors).

The utility emerging technology (ET) programs, funded by Public Good Charges at approximately \$4-5 million annually, contribute a considerable role in making many of these market connections possible, particularly when additional actions are needed to bridge from research and development to the marketplace. The intent of the ET program is to help accelerate the introduction of innovative energy efficient technologies, applications, and analytical tools that are not widely adopted in California through a variety of approaches, but mainly by reducing the performance uncertainties associated with new products and applications. For example, in some cases, performance validation is critical in order to increase market familiarity, reduce resistance to the innovation, and influence industry adoption of technologies. In other cases, end users need to see these emerging technologies in real applications before they are willing to adopt the technology. In still other cases, larger scale pilot demonstrations are necessary before industry and consumers have the confidence that the technology will perform well under various operating and climate conditions.

**Innovation** Source **Pathwavs** Marketplace Codes & **Standards CEC** End-Manufacturer, **Distributors PIER** Users **Utility** and Industry Energy **Emerging Efficiency** Technology Program Overseen by CPUC

Figure 2: CEC PIER's Pathways to the Marketplace Showing the Function of the ET Program

The ET programs address three sectors --commercial, residential, and industrial-- and in each of these three sectors, the potential for energy savings varies significantly by end use application. For example in the residential sector, air conditioning represents a major opportunity. It is estimated that air conditioning accounts for approximately 70% of the potential peak demand savings (Rufo and Coito 2002).

CEC PIER's mandate focuses PIER's activities on R&D. AB 1890, Article 7, established PIER to provide "Public interest research and development not adequately provided by competitive and regulated markets" and to provide for "the future market utilization of projects funded through the program." While PIER's primary focus and expenditure of funds has been in the R&D arena, the program recognizes the importance of "providing for future market utilization" of the research products and strives to continuously build bridges to the market either directly or through other public purpose programs such as those funded through the California utilities. The ET program at the

utilities has been an important channel for bridging PIER research products to the market (see **Figure 3**).

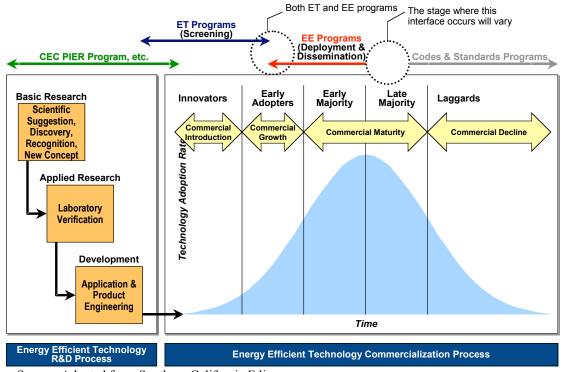


Figure 3: Energy Efficiency Technology R&D and Commercialization Process

Source: Adapted from Southern California Edison

By validating performance of new innovations and introducing them to end users, the ET program reduces unacceptable uncertainties and risk to the end user and serves a critical bridging function. The ET program's activities also influence the manufacturers, distributors and overall industry regarding viable approaches to improve energy efficiency. In this manner, the ET program and CEC PIER work hand-in-hand to encourage adoption of emerging technologies, provide a vital pathway to the marketplace that other direct paths do not address, and support CPUC in achieving the statewide energy efficiency potential.

**Figure 4 : Public Goods and Procurement Funding for Efficiency** depicts the relative funding for PIER energy efficiency activities, ET's current and proposed funding, and the funding for Energy Efficiency activities. The three red sections in each area reflect funding planning in the vintage of 2003; they do not reflect the more recent natural gas increases or the procurement increases (shown as cross-hatched sections). The current funding level of \$ 4 million (barley visible on the graph) is currently available for emerging technology demonstration projects.

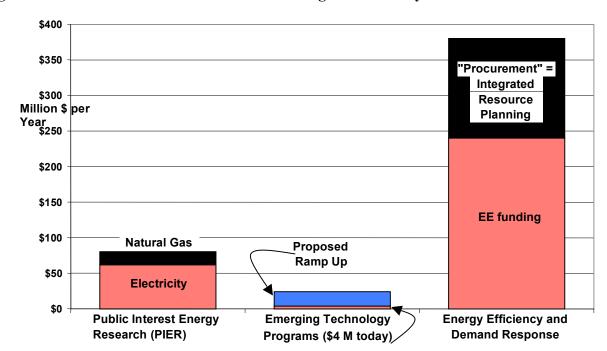


Figure 4: Public Goods and Procurement Funding for Efficiency

### Recommendation for Increased Funding

The CPUC should provide for higher levels of funding for emerging technologies because of the significant benefits that would accrue to the state's energy efficiency program and attainment of the kWh savings goal. Increased levels of funding for the ET programs are prudent because at the current levels of funding there are a large number of potentially beneficial innovations developed at CEC PIER that will not receive funding for pre-commercial demonstration. In general, of the 10-15 energy efficiency technologies that typically emerge annually from PIER research, approximately 75% are typically in jeopardy of not being bridged to the market place because of insufficient ET program funding. The implication is that potentially important opportunities for future energy savings in the state are being lost because of insufficient funding.

For example, to make this issue more tangible, we have identified a number of promising ET opportunities that have emerged or are in the process of emerging from PIER that could become lost, warehoused or severely diminished in the future if additional investments are not made via the ETCC (see **Table 2**). This list is not intended to be comprehensive (because there will be many more ET opportunities available), but it serves to simply illustrate the types of opportunities that exist.

Emerging technologies identified on this table include a sample of hardware, software, demand responsive strategies/tools, and design tools that are emerging from the public interest research stream.

The utility ET programs have successfully bridged some hardware technologies to the market through limited demonstrations. However, to validate performance and determine viability for future efficiency incentives, larger scale demonstrations are necessary.

Similarly, software tools that facilitate the design and operation of low energy systems are just emerging out of research but need to have more extensive pilot applications to validate savings and give industry confidence in the energy/cost benefits of the tools.

Demand responsive strategies are also emerging enabling better system reliability and giving consumers more control over their energy costs under time dependent price structures. As these strategies and tools emerge, performance and reliability must be clearly shown in diverse situations and service territories before the tools can be applied on a broad scale.

Finally, while design tools fall out of the traditional definition of emerging technologies, a significant number of such tools are emerging from the research stream and could play an important role in facilitating the design of more efficient HVAC and building systems. However, unless these tools are tested under various building, equipment, and site conditions and the information fully bridged to the design community, they may never be broadly implemented. While validation of design tools has not been a traditional ET role, it is an important bridging function between research and full market deployment that the utility ET programs could contribute a valuable role in.

For these identified innovations alone, it is estimated that annual expenditures in the range of \$12 – \$18 million in utility ET initiatives could play an invaluable role in effectively bridging these products into the marketplace. To be effective in reaching the marketplace, the ET initiatives need to go beyond the current small scale and small quantities of pilots and expand to larger scale projects that include more demonstrations (e.g., demonstrations that clearly validate performance, quantify more precisely the costs and benefits, inform key stakeholders and better inform policy) and provide an effective bridge to the marketplace.

It is difficult to predict the actual benefits of this investment, but we estimate that the overall benefit of commercializing the identified technologies could be in the range of **41-60 GWh** annual electric reduction (Table 2). Our estimate takes into account that not every technology identified in the table would be successful in the market and that successful commercialization is dependent on many factors (e.g. adoption by manufacturers and distributors, changes in codes, standards and standard operating practices) not just the demonstrations via the ET program.

PIER of course covers only a fraction of the available opportunities. Accordingly, we should enlarge the ET budget to be greater than the \$12-\$18 million of expected costs for the PIER opportunities (Table 2). As a conservative estimate for the years 2006-2008, PIER will contribute approximately half of the innovative ideas to the energy efficiency program, and therefore warrant a total emerging technology annual budget of approximately \$25 million (i.e., approximately twice the lower-end estimate of \$12 million for the PIER costs). The current annual funding level for ET is approximately 1% of the annual energy efficiency budget (the combined PGC and Procurement funds add to approximately \$400 million). The CEC recommends ramping up the funding level to

approximately 6% (i.e., \$25million)<sup>3</sup> of the annual budget by the year 2008 to provide higher levels of bridging between available upstream innovations and the marketplace resulting in better overall return on R&D investment and faster attainment of the kWh savings goals. The CEC proposes that the ETCC conduct intermediate reviews of the ET budget during this ramp up to do any necessary mid-course adjustments based on program performance and experience.

The CEC recognizes that policy changes will need to occur in order that the increased funding of ET does not adversely affect the utilities ability to meet their energy goals.

### Benchmarks from Successful Programs

We have identified three organizations that have demonstrated the potential value of emerging technologies activities as part of their publicly sponsored energy efficiency R&D programs. These programs provide general benchmarks of the potential benefits of a publicly sponsored program and provide some general guidance for enhancement of the program in California and for closing the gaps identified by the ACR.

The New York State Energy Research and Development Authority (NYSERDA) NYSERDA notes that there are significant barriers that impede realization of the full energy savings potential including limited research and development capabilities of building component and material suppliers; fragmentation of the design and construction industry; institutional barriers that limit adoption of innovative technologies; and lack of market participants due to unavailability of information, inappropriate price signals and market failures. NYSERDA's energy efficiency programs are specifically designed and operated to overcome these barriers (NYSERDA 2000).

NYSERDA spends approximately \$15 million annually on its emerging technologies program, or about 50% of the roughly \$30 million in annual funding for energy efficiency activities contained in NYSERDA's program.<sup>4</sup> This level of spending for emerging technologies activities is considerably greater than California's. In addition, unlike California, NYSERDA administers both the emerging technologies and incentives programs under a single organization and can seamlessly connect R&D

<sup>&</sup>lt;sup>3</sup> A small part of the proposed \$25M/year funding for ET will be handled by the new California Clean Energy Fund, ("CCEF"), a not-for-profit incubator, which PG&E is forming in compliance with the CPUC/PG&E settlement permitting PG&E to emerge from bankruptcy. [CPUC Decision 03-12-035, Dec. 12, 2003]. CCEF will be funded by PG&E at \$6M/year (or more) for at least 5 years. However, unlike the ETCC (as part of the Public Goods Charge Energy Efficiency Program), which is not expected to make a profit, the CCEF will function as an incubator and modest venture capital fund, hoping that a fraction of its portfolio will be profitable and will return the \$6M/year investment. So by the end of 5 years, CCEF hopes to have a rotating fund of at least \$30M. Thus of all the energy efficiency and environmentally friendly opportunities listed in Table I, CCEF will tend to focus on the patentable technologies at the top of the table and pass over the public domain software, design tools, and demonstrations which comprise the majority of the table. Further CCEF will not operate statewide; instead it will focus on helping developers in PG&E's service territory, leaving the ETCC to cover the rest of the state.

<sup>&</sup>lt;sup>4</sup> The overall NYSERDA program funding is much higher, around \$150 million annually; however, this includes significant funding for a several non-efficiency program elements including renewable energy. The NYSERDA estimate of \$30 million annual funding for energy efficiency includes the program elements that are comparable to California's energy efficiency program. Source: Private communication with Gunnar Walmet.

to needed deployment activities, including both emerging technology demonstrations as well as follow-on incentive programs.

**Table 2: Utility Emerging Technology Opportunities Flowing From PIER** 

(Facilitating Actions to Move Promising Emerging Technologies Into the Market)

	Emerging Technology	Examples of Actions Needed to Bridge Technology to the Market	Goal	Estimated Cost of ET Action (\$ millions)	Estimated Annual Electric Reduction (GWh)	Estimated Annual Savings (\$ Millions)
HARDWARE TECHNOLGIES	Integrated Classroom Lighting System  LED Task Light	15-20 Demonstrations in large service territories, 5-10 in smaller service territories (50 total).  Demonstrate technology in diverse occupancy types and	Validate energy savings, inform school districts of energy and non-energy benefits via field demonstrations. Determine viability for future incentives.  Verify energy savings under different operating conditions			
	Retrofit Kitchen Down lighting	user preferences. Determine user behavior within same building and in different building types. (200-300 installations).  Demonstrations to validate functionality and cost	and energy management scenarios. Determine viability for future incentives.  Demonstrate energy and nonenergy benefits to			
	System  Colored Cool	savings (lower first cost to builder and operating cost to consumer) (75-100 demonstrations).  Demonstrate technology	homebuyers and to builders. Determine viability for future incentives.  Inform builders and			
	Roofing Materials	with numerous builders in both low-income and custom homes. (Need large-scale demonstrations (75-100) so manufacturer can produce a broad range of products at low cost).	consumers of new aesthetically pleasing and energy efficient roofing materials (tile, asphalt, shake, metal). Determine viability for future incentives.	5 - 6	17 - 20	2 - 2.4
	Indirect-Direct Evaporative Cooling	Demonstrate technology in both residential (50) and commercial (50) applications.	Validate energy savings, provide verification to builders and facility managers that maintenance issues are resolved in new technology. Determine viability for future incentives.			
	Night Ventilation Cooling	Demonstrate night ventilation cooling as an energy efficiency alternative to compressor based cooling in coastal and transition zones (50). Demonstrate opportunity to reduce AC usage in inland climates (50).	Validate energy savings and indoor air quality improvements under various climate conditions. Inform builders and consumers of technology. Determine viability for future incentives.			
	Radiant Heating and Cooling	Demonstrate comfort and energy benefits in commercial applications (50).	Validate energy saving. Inform installers of cost effective installation characteristics of new technology. Determine viability for future incentives.			

**Table 2: Utility Emerging Technology Opportunities Flowing From PIER (continued)**(Facilitating Actions to Move Promising Emerging Technologies Into the Market)

	Emerging Technology	Examples of Actions Needed to Bridge Technology to the Market	Goal	Estimated Combined Cost of Utility ET Action (\$ millions)	Estimated Annual Electric Reduction (GWh)	Estimated Annual Savings (\$ Millions)
SOFTWARE TOOLS	Photo sensor Placement Software	Test software functionality under various room configurations in various occupancy types (50-75 installations).	Inform daylighting designers about the availability of a tool for optimizing photo sensor placement and validate tool functionality. Determine viability for inclusion in future savings by design options.			
	Whole Building Diagnostician	Demonstrate tool to detect and diagnose faults in air handlers (75-100 tests).	Validate performance, quantify energy savings potential, inform service providers and facility operators about the tool, and determine viability for future incentives.	2 - 3	7 - 10	0.8 - 1.2
	Low Energy Cooling System Design	Demonstrate viability of low energy design models in various occupancy types and building sizes (50-75 buildings).	Inform designers about the availability of a tool to facilitate the design of low energy cooling systems through pilot trials in real buildings. Determine viability for future savings by design options.			
TEGIES	Instant Start Electronic Ballast	Test ballast for effectiveness as a demand response technology through dimming T-8 fluorescent lamps. Test in 15-20 buildings.	Determine effectiveness as a demand response technology that utilities could offer to customers. Determine viability for future incentives.			
DEMAND RESPONSIVE STRATEGIES	DALI Lighting Control	Test protocols in controlling lighting levels beyond simple on/off control in 15-20 buildings.	Determine effectiveness as a demand response technology that utilities could offer to customers. Determine viability for future incentives.	2 - 4	7 - 13	0.8 - 1.6
	Demand Reduction by Pre- Cooling	Test pre-cooling strategies for effectiveness in reducing demand in 20-30 buildings.	Determine effectiveness as a demand response technology that utilities could offer to customers. Determine viability for future savings by design options.			

Table 2: Utility Emerging Technology Opportunities Flowing From PIER (concluded)

(Facilitating Actions to Move Promising Emerging Technologies Into the Market)

	Emerging Technology	Examples of Actions Needed to Bridge Technology to the Market	Goal	Estimated Combined Cost of Utility ET Action (\$ millions)	Estimated Annual Electric Reduction (GWh)	Estimated Annual Savings (\$ Millions)
DESIGN TOOLS	Large HVAC System Design Guide  Small HVAC System Design Guide  Skylight Design Guide	Pilot test newly developed design guide under various building sizes and system types for 15-20 buildings  Pilot test newly developed design guide under various building sizes and system types for 15-20 buildings  Pilot test newly developed design guide under various building sizes and system types for 15-20 buildings	Validate and quantify energy savings potential, inform designers about the energy savings potential when using the guide, and determine viability as a future savings by design option  Validate and quantify energy savings potential, inform designers about the energy savings potential when using the guide, and determine viability as a future savings by design option  Validate and quantify energy savings potential, inform designers about the energy savings potential, inform designers about the energy savings potential when using the guide, and determine viability as a future savings by design option	3 - 5	10 - 17	1.2 - 2
	Design Guide for Air Handling Systems	Pilot test newly developed design guide under various building sizes and system types for 15-20 buildings	Validate and quantify energy savings potential, inform designers about the energy savings potential when using the guide, and determine viability as a future savings by design option			
		Estimated Total		\$12 - \$18 Millions <sup>5</sup>	41-60 GWh	\$5-\$7 Millions

Source: CEC 2004

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<sup>&</sup>lt;sup>5</sup> Based on the estimates in Table 2 and identified opportunities from other non-PIER sources, to fund the full range of available technologies to the ET program would require funding of approximately \$25 million. The expenditures for the identified ET initiatives would typically occur in the near future (i.e., within 1-3 years). It typically requires many years before products saturate the market. The estimated Annual Electric Reduction and the Estimated Annual Savings are assumed to be realized when the product saturates the market after 5-15 years.

Lawrence Berkeley National Laboratories (LBNL)

LBNL provides a link between DOE building R&D activities and deployment initiatives. LBNL focuses a large portion of their R&D budget on demonstrating emerging energy efficiency technologies and transferring the knowledge to the market. Based on their performance self-assessment and the NRC study "Was it Worth It?" (NRC 2001) their program has allowed better and faster commercialization of the upstream technologies and advances and achieved high levels of payback.

For example, LBNL claims that their \$71 million R&D investment in the 1975-1985 decade in energy efficiency technologies, software and standards has led to significant savings and benefits (see **Table 3**). While some of the assumptions underlying this estimate are open to debate, the estimates provide a useful indication of the order of magnitude of realized energy savings that can be attained when new emerging technologies are not warehoused but, rather, transitioned successfully to the market (Lawrence Berkeley Laboratory 1995).

Table 3: LBNL Net Savings in U.S. from R&D Investment (1975-1985)

	\$ Billions	Multiple of Investment
Consumer savings achieved as of 1993	4.96	70
Lifetime savings for technologies installed through 1993	7.5	106
Lifetime savings for technologies installed through 2015	155	2,189

### DOE Energy Efficiency Research and Development

The National Research Council (NRC) undertook an assessment of the costs and benefits of energy efficiency research undertaken at DOE during the 22-year period from 1978 to 2000. The NRC study found that for the approximately \$7 billion (valued in 1999 dollars) spent as part of the DOE energy efficiency program, the estimated net realized economic benefits were approximately \$30 billion (valued in 1999 dollars)—approximately a four to one payback ratio. In addition to the realized economic benefits of the R&D, the study identified important environmental and security benefits as well as the creation of important knowledge that provided non-financial and policy benefits (National Research Council 2001).

### *Implications for California's emerging technologies initiatives*

To be successful, upstream R&D often requires pre-commercial deployment activities to build the bridge to the market and encourage market adoption of the emerging technologies. The energy efficiency programs at NYSERDA, LBNL and DOE all incorporate significant levels of pre-commercial bridging activities. In California, the utilities emerging technologies programs

coordinate by the ETCC provides the crucial bridge from CEC PIER's energy efficiency R&D to the market and assists in the commercialization of key energy efficiency technologies for the state.

### Closing

The CEC recommends ramping up the funding level to approximately 6% (i.e., \$25million) of the annual budget by the year 2008 to provide higher levels of bridging between available upstream innovations and the marketplace resulting in better overall return on R&D investment and faster attainment of the kWh savings goals. The CEC proposes that the ETCC conduct intermediate reviews of the ET budget during this ramp up to do any necessary mid-course adjustments based on program performance and experience.

There is a strong evidence to support the increased investment in emerging energy efficiency technologies in California. First, California's emerging technology and energy efficiency programs have been very effective in reducing electricity demand since 1975. Figure 1 shows that in electricity per capita, the U.S. has grown about 2% per year and California has succeeded in staying constant.

The review of the DOE and LBNL emerging technology programs demonstrates that there is strong, positive payback for RD&D programs of which commercialization is an essential part.

Finally, our assessment of selected emerging technology opportunities has identified important examples of opportunities for capturing additional energy efficiency potential in California. For the selected list of illustrative emerging technologies identified in Table 2, approximately 41-60 GWh annual electric reduction could be realized in the state. The estimated investment by the ET program to bridge only these technologies and emerging technologies from other sources is estimated to be \$25 million per year. It is important to note that at the current funding level for the ET program, approximately 75% of the 10-15 energy efficiency technologies that typically emerge annually from PIER research, are in jeopardy of not being adequately bridged to the market place. Bridging those technologies to the marketplace would result in better overall return on PIER's research investment and faster attainment of the kWh savings goal.

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CEC is pleased to have had this opportunity to provide its perspectives and recommendations regarding potential improvements to CPUC's policies and programs in energy efficiency emerging technologies. The CEC desires that this whitepaper provide the basis for collaborative discussions with the CPUC and further exploration of options for improvement.

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### Glossary

ACR: Assigned Commissioner's Ruling

CEC: California Energy Commission

CPUC: California Public Utilities Commission

DOE: US Department of Energy

ET: utilities' Emerging Technologies program funded by Public Good Charges

ETCC: Emerging Technologies Coordinating Council

GW: gigawatt

GWh: gigawatt hours

kW: kilowatt

kWh: kilowatt-hours

LBNL: Lawrence Berkeley National Laboratory

MW: megawatt

MWh: megawatt-hours

NRC National Research Council

NYSERDA: New York State Energy Research Development Authority

PIER: Public Interest Energy Research

# **Appendix Key Questions Raised by CPUC and Energy Commission Responses**

The ACR posited a group of insightful questions regarding energy efficiency emerging technologies following the first of a series of energy efficiency workshops<sup>1</sup>. Drawing from the innovation context, the examples presented earlier, and its experience, the California Energy Commission provides responses to selected questions raised by the CPUC.

1. How can the Commission (CPUC) encourage innovation and emerging technologies while assuring the state is using its limited resources wisely to fund proven efficiency technologies and programs?

**Energy Commission's Recommendation**: An increase in the funding level of the Emerging Technology Programs to \$25 million annually by 2007 would allow the state to better use its resources to capture more emerging technology-related benefits.

To improve energy efficiency in the state, the CPUC must continue to support short-term energy efficiency programs. However, in order to maximize energy efficiency potential and sustain continuing energy efficiency improvements, there must also be a longer-term vision that facilitates the market introduction of new and innovative solutions. The CPUC will be funding approximately \$400 million annually in energy efficiency programs and funding ET programs at approximately \$4-5 million annually for 2004-2005. The investment of the funds by the utilities is primarily focused on specific, pragmatic targets that yield relatively near-term savings (as guided by the CPUC's criteria).

The current investment in near-term savings is very important to meeting the savings goal but it is not sufficient to ensure long-term success or achieve the full statewide energy efficiency potential. The adoption of emerging technologies is a critical part of achieving high levels of energy efficiency because current technologies and energy management methodologies will only capture part of the potential savings. The overall potential net peak savings range from approximately 1,500 MW to over 4,500 MW based on energy efficiency program funding levels (Rufo and Coito 2002).

One of the key factors for long-term success is an increase in funding for ET programs and a related increase in activities focused on demonstration, validation and adoption of emerging energy efficiency innovations. The ET programs are the key mechanism available to the state to demonstrate and validate performance of innovations and to bridge the gap between R&D and commercial adoption of energy efficiency technologies. Energy Commission PIER is not

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<sup>&</sup>lt;sup>1</sup> The energy efficiency potential workshop was held on October 8, 2003. It was the first workshop in a series of workshops related to Rulemaking 01-08-028 conducted to determine how the CPUC may make the most of the state's energy efficiency resources in the years following 2005.

positioned to conduct these demonstrations or bridge the gap because, as was described earlier, PIER's role is focused on research.

Increasing funding for ET programs would contribute to meeting the state's kWh savings goal in three important ways:

- Provide an improved, small-scale proving ground for potentially significant energy efficiency innovations that are emerging from Energy Commission PIER research; this would validate performance prior to commitment of large investments and allow utilities to screen promising technologies for future energy efficiency program delivery.
- Demonstrate innovations that provide a medium- to long-term vision for energy
  efficiency and provide specific directions to innovators, regulators and policy makers of
  the potentially attractive, new areas of high value investment in energy efficiency
  innovation.
- Develop improved, sustained levels of collaboration between the CPUC, Energy Commission PIER and the utilities regarding the development and application of the best methods for increasing adoption of energy efficient emerging technologies, meeting the kWh savings goals and achieving the statewide energy efficiency potential.

These ET-related benefits could provide an increased level of kWh savings that would provide an integrated portfolio of short-, medium- and long-term savings and assist in meeting the state's savings goal. To garner these benefits, the ET program requires a budget that allows it to maintain a critical mass of activities. There is no established methodology to prescribe the appropriate budget size required to attain a critical mass. However, it is the Energy Commission's opinion that the current level of approximately \$4-5 million (i.e., approximately 1% of the \$400 million annual funding) is not sufficient. The current level of funding does not provide for adequate demonstration and validation of the majority of potentially valuable innovations that are available annually from the Energy Commission PIER program. A review of some of the unaddressed opportunities and the potentially large benefits that could be accrued from relatively modest increases in the budget indicates that funding for emerging technologies is well below critical mass (see the response to question #3 and **Table 1** for more details on the potential costs and benefits of unaddressed innovation opportunities).

It is important to note that long-lasting changes in energy use are required to meet the state's goals for energy savings. Short-term shifts in behavior in response to crises are not sufficient. For example, it was recently estimated that roughly 70% of the state's peak demand reduction in the summer of 2001 was attributable to short-term conservation behavior rather than long-lasting efficiency improvements (RAND 2002). While this reduction is laudable, without substantive changes in energy efficiency technologies, medium- to long-term behavior will return to pre-crisis norms and the demand will return to the higher levels.

To improve the situation and begin to capture more ET-related benefits, the Energy Commission recommends that the CPUC set a tentative goal for emerging technology funding of approximately \$25 million (approximately 6% of the \$400 million energy efficiency funding) and begin to increase the funding in steps e.g., increase funding to \$12 million

(approximately 3% of the \$400 million annual PGC/Procurement budget) in 2006, and schedule an increase to \$25 million (i.e., approximately 6% of the annual PGC/Procurement budget) in 2007 and beyond.

The benefits related to the increased funding would be assessed each year and used to decide if further increases in funding are warranted and if the timing and magnitude of the scheduled increases are appropriate or require modification. This low-risk, step-wise approach will allow the CPUC to improve performance in energy efficiency while learning the actual benefits of increased investment in emerging technologies.

2. Should emerging technologies program proposals be judged differently from other proposals?

**Energy Commission's Recommendation**: Because emerging technologies programs differ from the categories of hardware, incentive, information-only, and statewide marketing and outreach programs as defined in the CPUC's Energy Efficiency Policy Manual ("the Manual"), the CPUC should change the program proposal evaluation criteria to accommodate the bridging characteristics of emerging technologies programs and achieve a balanced portfolio of emerging and commercial technologies programs.

The August 2003 version of the Manual specified the following criteria for selecting information-only programs:

- 1. Ability to overcome market barriers
- 2. Equity
- 3. Innovation
- 4. Coordination with programs run by other entities
- 5. Quality and viability of program design
- 6. Distribution and reasonableness of budget
- 7. Program objectives and tasks clearly defined
- 8. Experience with successful delivery of similar programs
- 9. Alleviates transmission constraints in an area identified by the California Independent System Operator.

In the energy efficiency arena in California, "other" program proposals are aimed directly at providing long-term annual energy savings while program proposals for emerging technologies are aimed at providing a bridge between R&D and market adoption. Although in the long-term the bridging activity of the emerging technologies programs will lead to kWh savings, the bridging activity is a key focus of the proposed programs and affects their structure. These differences must be reflected in the evaluation criteria.

We propose the following seven criteria (excerpted from the Manual's selection criteria) for selection of a portfolio of emerging technologies programs:

- 1. Ability to overcome market barriers
- 2. Innovation
- 3. Coordination with programs run by other entities

- 4. Quality and viability of program design
- 5. Distribution and reasonableness of budget
- 6. Program objectives and tasks clearly defined
- 7. Experience with successful delivery of similar programs.

These seven selection criteria exclude two criteria from the Manual that would compromise the success of emerging technologies programs – equity and alleviating transmission constraints.

The equity criterion applies to large scale "production" programs that have potential to impact numerous people or businesses. In contrast, emerging technology programs focus on application assessment and demonstration projects that take place at a single site or a few sites. Site selection is driven by the availability of willing hosts who are willing to assume some risk as part of the project. Equity is better served if emerging technologies programs are conducted on the fastest possible track to site projects and deliver results that feed existing or new programs that address equity objectives.

Similarly, alleviating transmission constraints is a reasonable criterion for selection of statewide and local production programs that have potential to impact numerous people or businesses. Alleviating transmission constraints is better served if emerging technologies programs work on the fastest possible track to site projects and deliver results that feed existing or new programs that address alleviating transmission constraint objectives.

### Applicability of Cost Effectiveness as a Selection Criterion

As we have discussed earlier, emerging technologies programs do not fit neatly into the standard approach used for evaluating production programs. Although emerging technologies programs does not create immediate short-term energy savings, they provide clear, logical, and verifiable links between new or underused technologies and eventual energy savings.

As a result, emerging technologies programs cannot be adequately evaluated by the cost-effectiveness criteria that the Manual specifies for production programs. For example, it is difficult to estimate cost-effectiveness for an innovation as it is emerging from R&D; at that point, there are a number of potentially significant uncertainties, barriers, risks, and user concerns that frustrate precise estimates of cost-effectiveness. In addition, including the costs of ET programs in the utilities' program portfolio cost effectiveness calculations would penalize the utilities investing in ET because of the lower payback when calculated by traditional means.

Therefore, the CPUC's cost-effectiveness criteria may act as a barrier to effectively commercializing potentially important emerging technologies. As a result, the use of cost-effective criteria biases the selection of projects toward those with proven or commercially available technologies.

We propose exempting the costs of emerging technologies programs from the cost effectiveness computation used to assess utilities' statewide program portfolio TRC if the CPUC runs the program portfolio as they have done in recent years.

However, if future funding increases recommended elsewhere in this white paper result in the deployment of large-scale, multi-site technology pilots, we suggest that the CPUC allow utilities to claim energy savings and demand reduction benefits from successful pilots, where applicable, to reinforce portfolio cost effectiveness for ratepayers.

### **Evaluation Criteria for ET Programs**

The Statewide Emerging Technologies (ET) program seeks to accelerate the introduction of innovative energy efficient technologies, applications, tools and services that are not widely adopted in California. Innovations will be identified that create new energy efficiency opportunities to expand the current IOU energy efficiency portfolio.

The Energy Commission recommends that the CPUC adopt evaluation criteria for emerging technology proposals that are specifically designed to address the bridging functions of the proposed projects. Several candidate criteria could include:

1. Energy and demand savings will be estimated for the proposed innovations. Various methodologies may be implemented to accomplish this including, in situ measurements at customer sites, laboratory testing, and modeling. The variability of savings will be identified as it might be applied across a range of climate zones or applications. A wide error band may exist for the savings estimate and these estimates will be refined as more intelligence is developed.

Example: Based on a demonstration at a customer site, kWh and demand savings will be measured. Other variables addressed may include load profiles, resultant foot-candles, temperatures, etc.

## 2. Significant market barriers will be identified which may hinder the introduction of an innovation into the market.

Information and strategies to address these market barriers will be documented in order to reduce end user concerns. Market barriers may include, but not be limited to, performance uncertainties, reliability issues, maintenance issues, costs, etc. Close coordination between the ET Program staff, Energy Commission PIER Program/Project managers, and other technology development entities will facilitate a more seamless transition into the marketplace. PIER does R&D up to pilot testing and demonstrating basic functionality; ET does evaluation and demonstration projects and disseminates results for selected innovations that PIER or others have proposed for further commercialization. Identification of barriers may lead to a finding that an innovation is not ready for further commercialization. In this case, the ET Program will provide appropriate feedback to the developer or manufacturer on steps or modifications needed for commercialization.

- 3. Intelligence will be developed and activities initiated for feeding market programs including, but not limited to, Energy Efficiency Production Programs, Codes & Standards activities, as well as other commercialization efforts.

  Innovation assessments that are hardware related will likely contribute to developing the engineering criteria required to determine program cost effectiveness. Other intelligence may be required for tools or services.
- 4. The Emerging Technologies Coordinating Council (ETCC) will meet quarterly. This forum allows for the stakeholders (SCE/PG&E/SEMPRA/Energy Commission-PIER) to coordinate statewide activities, share information on active PIER projects including expected completion dates, review and coordinate regulatory requirements, discuss preliminary assessment results, strategize regarding program introduction opportunities, etc.
- 5. The ETCC website will be updated regularly with current information.

  As assessments are completed, project results will be posted so other stakeholders and interested parties can access relevant information. Information and activities posted on the website will serve to make the operations transparent to interested parties.
- 3. Should the Commission (CPUC) set aside funding levels for emerging technologies?

### **Energy Commission's Recommendations**

- The CPUC should provide for higher levels of funding for emerging technologies and allow the utilities the flexibility to fund additional opportunities as they become apparent.
- The CPUC should expand and improve number, scope and breadth of the ET project activities.

The CPUC should provide for higher levels of funding for emerging technologies because of the significant benefits that would accrue to the state's energy efficiency program and attainment of the kWh savings goal. However, rather than restrict funding to specific set-aside levels, the CPUC should provide the utilities the flexibility to fund additional opportunities as they become apparent. The CPUC should provide the utilities guidelines to govern their decisions regarding the additional funding and the CPUC should annually review the utilities' funding activities.

As was discussed in the main text of the document, increased levels of funding for the ET programs are prudent because at the current levels of funding there are a large number of potentially beneficial innovations developed at Energy Commission PIER that will not receive funding for pre-commercial demonstration. In general, of the 10-15 energy efficiency technologies that typically emerge annually from PIER research, approximately 75% are typically in jeopardy of not being bridged to the market place because of insufficient ET program funding. The implication is that potentially important opportunities for future energy

savings in the state are being lost because of insufficient funding. **Table 2** (main text of the whitepaper) provides specific examples of promising ET opportunities that have emerged or are in the process of emerging from PIER that could become lost, warehoused or severely diminished in the future if additional investments are not made via the ETCC. This list is not intended to be comprehensive (because there will be many more ET opportunities available), but it serves to simply illustrate the types of opportunities that exist.

As was previously discussed, for these innovations and other innovations, it is estimated that expenditures on the order of \$25 million in utility ET initiatives could play an invaluable role in effectively bridging these products into the marketplace. To be effective in reaching the marketplace, the ET initiatives need to go beyond the current small scale and small quantities of pilots and expand to larger scale projects that include more demonstrations (e.g., demonstrations that clearly validate performance, quantify more precisely the costs and benefits, inform key stakeholders and better inform policy) and provide an effective bridge to the marketplace.

We estimate that the overall benefit of commercializing these technologies could be approximately 41-60 GWh annual electric reduction. Our rough estimate takes into account that not every technology identified in the table would be successful in the market and that successful commercialization is dependent on many factors (e.g. adoption by manufacturers and distributors, changes in codes, standards and standard operating practices) not just the demonstrations via the ET program.

As noted earlier, the current annual funding level for ET is approximately 1% of the annual energy efficiency budget. Raising the funding level to 6% of the annual budget gradually over the next 4-5 years would provide higher levels of bridging between available upstream innovations and the marketplace resulting in better overall return on R&D investment and faster attainment of the kWh savings goal.

In addition, to better capture the value of the energy efficiency R&D investments, the CPUC should improve the effectiveness of the utility emerging technology programs' bridging activities between R&D and the commercial marketplace. Specifically the CPUC should expand and improve the ET activities to include:

- Increasing the number of stand-alone hardware demonstration projects to expand the demonstration information available to policy makers, regulators, utilities, Energy Commission and stakeholders
- Expanding the scope of emerging technology projects to include production scale projects (i.e., multi-unit demonstrations that can be used to elicit customer feedback, identify manufacturing issues) to provide significant new types of information to decision makers and to increase the rate of technology adoption
- Expanding the breadth of the emerging technology projects to include more than hardware (e.g., software technologies, construction techniques, alternate strategies) and the use of alternate or amended criteria by utilities to provide a broader range of potentially valuable changes that will increase the effectiveness of California's energy efficiency emerging technology program.

California is not alone in addressing this pre-commercialization issue. As the benchmarking of other programs demonstrated, successful organizations need to focus a significant portion of their budget and programmatic effort on demonstrating and validating emerging technologies and transferring the knowledge to the market. These contribute to better and faster market adoption of the innovations, higher levels of payback on the R&D and greater levels and rates of energy savings.

4. Should programs using emerging technologies be on a different schedule than other programs?

**Recommendation:** ET programs should be on multi-year schedules with annual updates and reviews.

Yes, a different schedule is warranted for emerging technology projects. Typically, traditional projects in energy efficiency delivery programs can be completed and the results known in less than a year. However, emerging technology projects may require longer reaching fruition (. For example, with emerging technology projects, the focus on forming the bridge between R&D and the marketplace and the inclusion of project goals related to validation, demonstration, removing barriers and informing energy efficiency programs, mean that many of the projects may require approximately 2-4 years to complete and for the results to be evident (and is consistent with the macro-funding cycle of 3 years for the program). Based on experience in the field, some demonstration projects require up to four years to complete, commencing on the date an agreement is signed with a customer through construction scheduling, building and process commissioning, logistics, etc. Subsequently, information from the project needs to be transferred to accessible databases and disseminated to the market and key stakeholders.

In addition, because emerging technology projects often address important uncertainties and have a higher level of complexity as a result of the bridging activities a greater degree of schedule flexibility needs to be included in the projects.

Requiring that emerging technology projects conform to the traditional schedule of a year or less could reduce the overall effectiveness and value of many emerging technology projects or it could make some potentially valuable projects unfeasible because of time constraints.

5. How should emerging technologies be better integrated into "mainstream" programs and services?

**Energy Commission's Recommendation:** Establish performance criteria that result in stronger collaboration and integration between the ET programs, energy efficiency delivery programs, and Energy Commission PIER.

Better integration into mainstream programs and services will require that CPUC establish stronger performance criteria for collaboration in the energy efficiency delivery program evaluation metrics. Consider that the current performance criteria for the ET Programs include

collaboration with other programs. For example, ET program managers need to demonstrate linkage and collaboration with Energy Commission PIER as a key part of their operations. This collaboration performance metric has promoted effective collaboration and integration between ET program managers and the Energy Commission PIER program via the ETCC. The CPUC should adopt the same approach to increase integration into mainstream programs and services and employ metrics specifically targeted at the quantity and quality of collaboration between CPUC, emerging technology programs, energy efficiency delivery programs, and Energy Commission PIER.

In addition, the CPUC should consider encouraging approaches that would complement the improved performance criteria, including:

- Inclusion of a transition plan in the emerging technology projects that provides for effective integration into energy efficiency delivery programs and services such as Savings by Design and Express Efficiency
- Enhanced common understanding among the three groups (CPUC, ETCC and Energy Commission PIER) of the barriers and opportunities related to increased integration; the enhanced understanding would increase the level and quality of collaboration and, ultimately, the improved integration of emerging technologies into mainstream programs and services.
- 6. How, if at all, should the Energy Commission and the Commission(CPUC) coordinate efforts to develop new technologies using PIER funding and then spur their development via public goods charge funding?

**Energy Commission's Recommendation:** Continue to support the role of the ETCC as a forum for enhanced communication between PIER and the ET programs and strengthen the integration with energy efficiency delivery programs.

The ETCC is currently successful in establishing a venue for CPUC and Energy Commission PIER coordination and collaboration (via the utilities). The ETCC approach works well although, as we have described in response to the previous questions, performance would be enhanced via changes to the criteria, metrics, schedule and other aspects. To further enhance coordination and spur development, CPUC should:

- Continue to use ETCC as a venue for two-way communication between PIER and Utilities. Utilities can inform PIER about needed research based on their experience with customers and PIER can conduct research and transfer the results back to the utilities in order to reach the end-user
- Establish stronger communications between PIER and energy efficiency delivery programs
- Establish stronger communications between ET programs and energy efficiency delivery programs.

We have identified several important ways to close those gaps identified by the CPUC in the ACR.

- Gap #1: The state is not currently maximizing its energy savings potential.

  Potentially important opportunities for future energy savings in California are being lost because of insufficient funding of ETCC that results in significantly decreased transfer of potentially useful innovations to the marketplace.
- Gap #2: The state will need to promote more innovation in emerging energy efficiency technologies.
   Greater innovation in energy efficiency will occur when energy efficiency R&D activities are effectively linked to the end-user marketplace via well-funded, effective and integrated ET programs.
- Gap #3: Some of the Commission's (CPUC) existing policies should be modified to
  maximize opportunities to promote energy savings.

  Improving the CPUC's policies for evaluating and selecting energy efficiency projects will
  have positive, sustained effects on the quantity and quality of emerging technologies that
  are commercialized and produce higher levels of kWh savings in the medium- and longterm.

In responding to the selected questions in the ACR, The Energy Commission recommended seven important interrelated improvements to the CPUC's approach for emerging technologies.

- Increase the funding level of ETCC to \$25 million annually by 2007.
- Change the proposal evaluation criteria to accommodate the bridging characteristics of emerging technologies and achieve a balanced desired portfolio of emerging and commercial technologies.
- Provide for higher levels of funding for emerging technologies by allowing the IOU's to fund additional opportunities as they become apparent.
- Expand and improve the number, scope and breadth of the ET activities.
- Establish multi-year schedules for ET programs with annual updates and reviews.
- Establish performance criteria that result in stronger collaboration and integration between CPUC, ET programs, energy efficiency delivery programs, and Energy Commission PIER.
- Continue to support the role of ETCC as a forum for enhanced communication between PIER and the ET programs and strengthen the integration with energy efficiency delivery programs.